

# Heart Rhythm Coherence Feedback:

## A New Tool for Stress Reduction, Rehabilitation, and Performance Enhancement

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### An Introduction to Heart Rate Variability Feedback

Heart rate variability feedback is an exciting new technology that has broad-based applications in stress reduction, rehabilitation, and performance enhancement. This article focuses on heart rhythm coherence feedback training, which has proven to facilitate rapid, profound, and enduring improvements in a wide variety of conditions. An important reason this technology is effective in so many and diverse applications is that it facilitates the maintenance of a physiologically efficient and highly regenerative inner state, characterized by reduced nervous system chaos and increased synchronization and harmony in system-wide dynamics. This psychophysiological mode, termed *physiological coherence*, is conducive to healing and rehabilitation, emotional stability, and optimal performance. This article provides an introduction to heart rate variability feedback, explores its advantages, and discusses the use of heart rhythm coherence feedback to promote the physiological coherence mode. A new heart rhythm coherence monitoring and feedback system known as the Freeze-Framer is introduced, and examples of the effective use of this technology to reduce stress and promote positive emotional states and coherence in a wide

range of wellness and performance enhancement applications are presented.

### Significance and Measurement of Heart Rate Variability

Heart rate variability (HRV) is a measure of the naturally occurring beat-to-beat changes in heart rate. The analysis of HRV, or heart rhythms, is a powerful, noninvasive measure of neurocardiac function that reflects heart-brain interactions and autonomic nervous system dynamics.<sup>1-3</sup> HRV can be derived either from the electrocardiogram (ECG), using electrodes placed on the chest, or from pulse wave recordings, using a plethysmographic optical sensor placed at the fingertip or earlobe. ECG recordings have the advantage of producing fewer movement-related artifacts. However, pulse wave recording devices also provide data suitable for most applications, and, as they require no electrode hook-up, are more easily adaptable for use in a much wider variety of settings (see below).

### Advantages of HRV Feedback

A promising advancement in biofeedback technology is the recent development of HRV feedback systems. In relation to other types of biofeedback, HRV feedback offers several unique advantages. First, HRV feedback reflects the activity of both the sympathetic and parasympathetic branches of the autonomic nervous system and the synchronization between them, and thus provides a window into the dynamics of the system

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as a whole. Compared to EEG feedback, HRV feedback is also considerably simpler and more straightforward to learn and use, which facilitates rapid improvement. Further, because the instrumentation utilizes only a simple pulse sensor requiring no electrode hook-up, it is extremely versatile and can be used easily and effectively as an educational tool not only in clinical settings but also in the home, in the workplace, in schools, or even while traveling. Its cost-effectiveness also makes it accessible to a greater number of people and in a wide range of applications. In relation to other biofeedback modalities, HRV feedback is also more reflective of changes in emotional/psychological state, and thus is particularly powerful in applications where reducing stress and increasing emotional stability are critical.

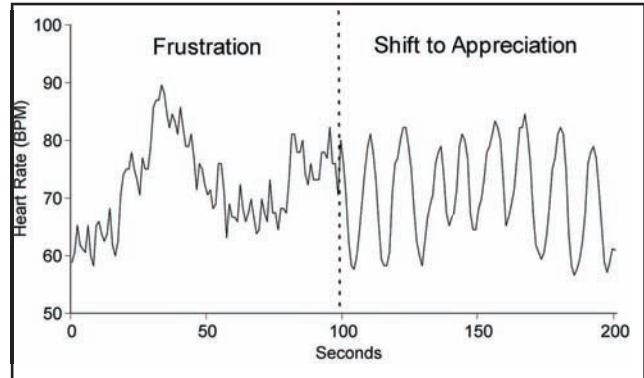
### Heart Rhythm Pattern Analysis

Typically, instruments used for recording HRV analyze the signal by means of time domain or frequency domain (spectral) analysis, both of which quantify the *amount* of variability in heart rate that exists in a given recording. A new approach to HRV monitoring and feedback is the analysis of heart rhythm *patterns*. Heart rhythm pattern analysis, which analyzes the varying shape of the HRV waveform, is an especially useful tool in psychophysiological research and biofeedback applications. This type of analysis can be particularly valuable in applications that aim to illuminate the physiological correlates of different mental and emotional states, assess the extensive interactions among the mental, emotional, and physiological systems in arousal-induced pathology, or examine psychophysiological responses to different interventions.

### HRV and Emotions

Recent research conducted at the Institute of HeartMath has demonstrated that HRV dynamics are particularly sensitive to changes in emotional state, and that positive and negative emotions can be readily distinguished by changes in heart rhythm patterns which are independent of heart rate. Specifically, during the experience of negative emotions such as anger, frustration, or anxiety, heart rhythms become more erratic or

disordered, indicating less synchronization in the reciprocal action between the parasympathetic and sympathetic branches of the autonomic nervous system. In contrast, sustained positive emotions, such as appreciation, love, or compassion, are associated with a highly ordered or *coherent* pattern in the heart rhythms, reflecting greater synchronization between the two branches of the autonomic nervous system.<sup>2,3</sup>



**Figure 1. Shift to coherence.** Real-time heart rate variability (heart rhythm) pattern of an individual making an intentional shift from a self-induced state of frustration to a genuine feeling of appreciation by using HeartMath’s Freeze-Frame positive emotion refocusing technique (at the dotted line). It is of note that when the recording is analyzed statistically, the *amount* of heart rate variability is found to remain virtually the same during the two emotional states; however, the *pattern* of the heart rhythm changes distinctly. Note the immediate shift from an erratic, disordered heart rhythm pattern associated with frustration to a smooth, harmonious, sine wave-like (coherent) pattern as the individual uses the positive emotion refocusing technique and self-generates a heartfelt feeling of appreciation.

### Physiological Coherence

Our research on HRV and emotion has identified a distinct mode of physiological functioning that is frequently associated with the experience of sustained positive emotion. We call this mode *physiological coherence*.<sup>4,5</sup> “Coherence” is used here as an umbrella term to describe a physiological mode that encompasses a range of distinct but related phenomena, including synchronization, entrainment, and resonance, all of which emerge from the harmonious interactions of the body’s subsystems. Correlates of physiological coherence include: increased synchronization between the two branches of the autonomic nervous system, a shift in autonomic balance toward increased parasympathetic activity, increased heart–brain synchronization (alpha rhythms become more

synchronized to the ECG), increased vascular resonance, and entrainment among diverse physiological oscillatory systems (*i.e.*, heart rhythm patterns, respiratory, craniosacral, and blood pressure rhythms).<sup>3, 5</sup> The coherent mode is reflected by a smooth, sine wave-like pattern in the heart rhythms (heart rhythm coherence) and a narrow-band, high-amplitude peak in the low frequency range of the HRV power spectrum, at a frequency of about 0.1 hertz.

In terms of physiological functioning, the coherent mode confers a number of benefits to the system. These include: (1) resetting of baroreceptor sensitivity, which is involved in short-term blood pressure control and has also been found to be related to increased respiratory efficiency;<sup>6</sup> (2) increased vagal afferent traffic, which is involved in the inhibition of pain signals and sympathetic outflow;<sup>5</sup> (3) increased cardiac output in conjunction with increased efficiency in fluid exchange, filtration, and absorption between the capillaries and tissues; (4) increased ability of the cardiovascular system to adapt to circulatory requirements; and (5) increased temporal synchronization of cells throughout the body.<sup>7, 8</sup> This results in increased system-wide energy efficiency and metabolic energy savings. The physiological coherence mode has also been associated with psychological benefits such as increased emotional stability and improved cognitive performance.<sup>5, 9-11</sup>

### Coherence-Building Techniques

Although physiological coherence is a natural state that can occur spontaneously, sustained episodes are generally rare. While specific rhythmic breathing methods can induce coherence and entrainment for brief periods, cognitively-directed paced breathing is difficult for many people to maintain for more than about one minute. On the other hand, our findings indicate that individuals can maintain extended periods of physiological coherence by actively self-generating and sustaining a positive emotional state, such as appreciation, care, or love. Using a positive emotion to drive the coherent mode appears to excite the system at its resonant frequency, and coherence emerges naturally, making it easy to sustain for long periods.

Based on these findings and related research on the extensive interactions between the heart and brain,<sup>12</sup> the Institute of HeartMath has developed a set of positive emotion-focused techniques that foster physiological coherence. Collectively known as the HeartMath system, these techniques utilize the heart as a point of entry into the psychophysiological networks that underlie emotional experience.<sup>4, 13, 14</sup> In brief, HeartMath techniques combine a shift in the focus of attention to the area around the heart (where many people subjectively feel positive emotions) with the intentional self-induction of a sincere positive emotional state, such as appreciation. Such a shift in focus and feeling serves to prevent or reduce the stress response and increase heart rhythm coherence, which results in a change in the pattern of afferent cardiac input sent to the cognitive and emotional centers in the brain. This coupling of a more organized afferent pattern with an intentionally self-generated feeling of appreciation reinforces the natural conditioned response between the physiological state and the positive emotion. This subsequently strengthens the ability of a positive feeling shift to initiate a physiological shift towards increased coherence, or a physiological shift to facilitate the experience of a positive emotion. With practice, the new coherent patterns become increasingly familiar to the brain and nervous system, and thus become established in the neural architecture as a new, stable baseline or norm.

Evidence from studies conducted across diverse populations suggests that this repatterning process can lead to both short-term and long-term improvements in key measures of physical and emotional health. For example, individuals using HeartMath coherence-building techniques have demonstrated significant reductions in stress, anxiety, and depression;<sup>9, 10, 15-21</sup> increases in positive affect and attitudes;<sup>9, 10, 15-21</sup> enhancement of humoral immunity;<sup>22, 23</sup> and an increased DHEA/cortisol ratio.<sup>9</sup> By reducing stress and its physiological effects, these interventions have also been shown to produce significant improvements in health status in various clinical populations (discussed further below).

## Heart Rhythm Coherence Feedback Training

Heart rhythm coherence feedback training is a powerful tool to help people learn to self-generate states of increased physiological coherence at will, thereby reducing stress and improving health, emotional well-being, and performance. A new HRV feedback system known as the Freeze-Framer (Quantum Intech, Inc., Boulder Creek, CA) incorporates a patented technology that enables physiological coherence to be objectively monitored and quantified. Using a fingertip or earlobe plethysmographic sensor to detect the pulse wave, this interactive hardware/software system plots changes in heart rate on a beat-to-beat basis. Both the heart rate tachogram and the HRV power spectrum can be viewed in real time. The software also includes a tutorial that provides instruction in the HeartMath positive emotion-focused coherence-building techniques. As users practice the techniques, they can readily see and experience the changes in their heart rhythm patterns, which generally become less irregular, smoother, and more sine wave-like as they enter the coherent mode. This process enables individuals to easily develop an association between a shift to a more healthful and beneficial physiological mode and the positive internal feeling experience that induces such a shift. The software also analyzes the heart rhythm patterns and calculates a coherence ratio for each session. The coherence level is fed back to the user as an accumulated



Figure 2. The Freeze-Framer® heart rhythm coherence feedback trainer.

score or success in playing one of three colorful on-screen games designed to reinforce coherence-building skills. Finally, the system includes a multi-user database to store results and track clients' progress.

Because this technology uses a pulse wave monitor and involves no electrode hook-up, it is extremely versatile, time-efficient, and easy to use in a wide variety of settings to reduce stress, improve health, and optimize performance. For example, the Freeze-Framer has been successfully used by mental health professionals, physicians, educators, corporate executives, athletes, and performing artists.

### *Medical applications*

Many health professionals have found heart rhythm coherence feedback to be an effective tool to educate patients in the physiological effects of stress and emotions, and thus to support and facilitate a wide variety of therapies, both conventional and complementary. For example, the Freeze-Framer technology is increasingly being used by neurofeedback practitioners to calm clients and stabilize the nervous system before sessions; this preparation often allows for a shorter and more effective session. Many clinicians have found heart rhythm coherence feedback to be an effective addition to treatment programs for chronic conditions that are associated with or exacerbated by emotional stress, including fibromyalgia, chronic fatigue, hypertension, asthma, environmental sensitivity, sleep disorders, diabetes, and cardiac arrhythmias, among many others. The system has proven particularly effective in pain management and is currently used in burn clinics. Finally, the Freeze-Framer is employed in cardiac rehabilitation programs to help patients reduce stress and increase cardiovascular efficiency. Clinical studies have shown significant improvements in functional capacity in patients with congestive heart failure<sup>15</sup> and significant blood pressure reductions in hypertensive individuals<sup>16</sup> using the Freeze-Framer in conjunction with the HeartMath coherence-building techniques.

### *Mental health applications*

Heart rhythm coherence feedback is also a powerful educational tool in mental health settings and has facilitated rapid and profound improvements in individuals with such conditions as depression, anxiety, panic disorder, post-traumatic stress disorder, and attention-deficit hyperactivity disorder (ADHD). Many mental health specialists have commented that children appear to be particularly responsive to the Freeze-Framer, as input on their heart's rhythms is often more tangible and engaging to them in comparison to other biofeedback modalities. The system is also frequently used to facilitate anger management and impulse control.

Because of the sensitivity of HRV patterns to changes in psychophysiological state, many psychologists utilize heart rhythm monitoring effectively as a "camera on the emotions." Continuous monitoring of clients' HRV throughout a therapy session is easily accomplished and can give both therapist and clients immediate insight into clients' emotional responses, often enabling a more efficient and effective session. This technology often proves helpful in identifying subconscious feelings, reactions, and emotional triggers that operate at a level below an individual's conscious awareness but are nevertheless reflected in physiological patterns and processes. The sensitivity of heart rhythm monitoring to psychological variables is clearly illustrated by the account of one psychologist who uses this technology with clients with multiple personality disorder. This clinician finds that he is able to reliably distinguish between the different personalities his clients manifest on the basis of distinct changes in their heart rhythm patterns.

### *Performance enhancement applications*

In addition to improving physical and emotional health, heart rhythm coherence feedback is also used in optimizing performance in a wide variety of domains. By reducing performance-related anxiety and mental "noise," stabilizing nervous system dynamics, and creating system-wide coherence, this intervention helps individuals learn to self-generate and sustain high-performance states at will. One application in which this

intervention has proven particularly effective is helping students stabilize the nervous system to reduce anxiety and improve performance in high-stakes test-taking. Pilot studies with high school students have shown a 14% to 35% increase in standardized test scores in reading and math after 8 hours of training (over a 3-week period) with the Freeze-Framer and HeartMath coherence-building techniques.<sup>24, 25</sup>

Another rapidly growing application for heart rhythm coherence feedback is in the area of sports performance enhancement. Helping athletes learn how to consistently enter a peak-performance state that maximizes emotional stability, focus, concentration, and physical coordination, the Freeze-Framer has made a particularly notable impact in the professional golfing community.<sup>26</sup>

### **The Promise of Heart Rhythm Coherence Feedback**

In summary, HRV feedback is a versatile and cost-effective technology that has broad-based applications in clinical, workplace, sports, and academic settings for the enhancement of health and human performance. Because it can be easily used to promote a psychophysiological state conducive to stress reduction, thereby promoting physical, mental, and emotional regeneration, we foresee that heart rhythm coherence feedback training will be increasingly incorporated in many types of rehabilitation and disease prevention programs, as well as in the treatment of emotional disorders. We also expect that its use will grow in education, with the increase in state-mandated standardized testing in the U.S. and the growing awareness of the importance of educating youth in emotion regulation skills. Finally, using HRV feedback to learn to self-generate physiological coherence has innumerable potential applications in performance enhancement. In short, heart rhythm coherence feedback is a practical and powerful tool to facilitate people in developing a greater awareness of the connection between their emotions, physiology, and behavior, and ultimately to achieve greater mastery of their health and well-being.

*HeartMath is a registered trademark of the Institute of HeartMath. Freeze-Framer is a registered trademark of Quantum Intech, Inc.*

For more information on the Institute of HeartMath, research publications, and the Freeze-Framer heart rhythm coherence feedback system, visit our web site at: [www.heartmath.org](http://www.heartmath.org).

## References

1. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *Circulation* 1996;93:1043-1065.
2. McCraty R, Atkinson M, Tiller WA, Rein G, Watkins AD. The effects of emotions on short-term heart rate variability using power spectrum analysis. *American Journal of Cardiology* 1995;76(14):1089-1093.
3. Tiller WA, McCraty R, Atkinson M. Cardiac coherence: A new, noninvasive measure of autonomic nervous system order. *Alternative Therapies in Health and Medicine* 1996;2(1):52-65.
4. McCraty R, Childre D. *The appreciative heart: The psychophysiology of positive emotions and optimal functioning*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 02-026, 2002.
5. McCraty R, Atkinson M. *Psychophysiological coherence*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication 03-016, 2003.
6. Lehrer PM, Vaschillo E, Vaschillo B, Lu S-E, Eckberg DL, Edelberg R, Shih WJ, Lin Y, Kuusela TA, Tahvanainen KUO, Hamer RM. Heart rate variability biofeedback increases baroreflex gain and peak expiratory flow. *Psychosomatic Medicine* 2003;65(5):796-805.
7. Langhorst P, Schulz G, Lambertz M. Oscillating neuronal network of the “common brainstem system.” In: Miyakawa K, Koepchen HP, Polosa C, eds. *Mechanisms of Blood Pressure Waves*. Tokyo: Japan Scientific Societies Press, 1984: 257-275.
8. Siegel G, Ebeling BJ, Hofer HW, Nolte J, Roedel H, Klubendorf D. Vascular smooth muscle rhythmicity. In: Miyakawa K, Koepchen HP, Polosa C, eds. *Mechanisms of Blood Pressure Waves*. Tokyo: Japan Scientific Societies Press, 1984: 319-338.
9. McCraty R, Barrios-Choplin B, Rozman D, Atkinson M, Watkins AD. The impact of a new emotional self-management program on stress, emotions, heart rate variability, DHEA and cortisol. *Integrative Physiological and Behavioral Science* 1998;33(2):151-170.
10. McCraty R, Atkinson M, Tomasino D, Goelitz J, Mayrovitz HN. The impact of an emotional self-management skills course on psychosocial functioning and autonomic recovery to stress in middle school children. *Integrative Physiological and Behavioral Science* 1999;34(4):246-268.
11. McCraty R. Influence of cardiac afferent input on heart-brain synchronization and cognitive performance. *International Journal of Psychophysiology* 2002;45(1-2):72-73.
12. McCraty R. *Heart-brain neurodynamics: The making of emotions*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 03-015, 2003.
13. Childre D, Martin H. *The HeartMath Solution*. San Francisco: HarperSanFrancisco, 1999.
14. Childre D, Rozman D. *Overcoming Emotional Chaos: Eliminate Anxiety, Lift Depression and Create Security in Your Life*. San Diego: Jodere Group, 2002.
15. Luskin F, Reitz M, Newell K, Quinn TG, Haskell W. A controlled pilot study of stress management training of elderly patients with congestive heart failure. *Preventive Cardiology* 2002;5(4):168-172, 176.
16. McCraty R, Atkinson M, Tomasino D. Impact of a workplace stress reduction program on blood pressure and emotional health in hypertensive employees. *Journal of Alternative and Complementary Medicine* 2003;9(3):355-369.
17. Rozman D, Whitaker R, Beckman T, Jones D. A pilot intervention program which reduces psychological symptomatology in individuals with human immunodeficiency virus. *Complementary Therapies in Medicine* 1996;4(4):226-232.
18. McCraty R, Atkinson M, Lipsenthal L. Emotional self-regulation program enhances psychological health and quality of life in patients with diabetes. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 00-006, 2000.
19. Barrios-Choplin B, McCraty R, Cryer B. An inner quality approach to reducing stress and improving physical and emotional wellbeing at work. *Stress Medicine* 1997;13(3):193-201.
20. Barrios-Choplin B, McCraty R, Sundram J, Atkinson M. The effect of employee self-management training on personal and organizational quality. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 99-083, 1999.
21. McCraty R, Atkinson M, Tomasino D. *Science of the Heart: Exploring the Role of the Heart in Human Performance*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 01-001, 2001.
22. Rein G, Atkinson M, McCraty R. The physiological and psychological effects of compassion and anger. *Journal of Advancement in Medicine* 1995;8(2):87-105.
23. McCraty R, Atkinson M, Rein G, Watkins AD. Music enhances the effect of positive emotional states on salivary IgA. *Stress Medicine* 1996;12(3):167-175.
24. Arguelles L, McCraty R, Rees RA. The heart in holistic education. *Encounter: Education for Meaning and Social Justice* 2003;16(3):13-21.
25. McCraty R, Tomasino D, Atkinson M, Aasen P, Thurik SJ. Improving test-taking skills and academic performance in high school students using HeartMath learning enhancement tools. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 00-010, 2000.
26. *Managing Emotions—Golf’s Next Frontier: Ground-Breaking Techniques for High Performance*. Boulder Creek, CA: HeartMath LLC, 2003.